



Quick Reference Guide 2

Excel 2013 Formulas Overview



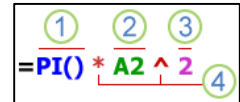
An Excel Formula,¹ or equation, can range from basic math to complex engineering, programming and statistical calculations. A formula always starts with an **equal** sign (=). Formulas are created by entering in a cell the data to be used in the calculations and the mathematical operators that tell Excel which operation to perform and in what order.

Basic math equations are covered in the Excel 2013 for Windows QRG1 – It Starts with a Cell.

Due to the “Order of Operations” (or PEMDAS – Parentheses, Exponents, Multiplication, Division, Addition, Subtraction), Excel performs calculations in a specific order. More about the Order of Operations is available in the section entitled “Order of Operations in Formulas” at page 2.

Parts of a Formula

The formula shown right contains:



1. Functions: a prewritten formula that performs an operation on a value or values and returns a result or results. Use functions to simplify or shorten formulas, especially those that perform lengthy or complicated calculations.	The PI() function returns the value of pi = 3.142...
2. References: a combination of the column letter identifier and the row number identifier returns the value of the identified cell.	A2 returns data in cell A2 .
3. Constants: a value that is not calculated and, therefore, does not change. The number “\$6,435” and the text “Monthly Gross Income” are constants.	Values entered directly in a formula, such as 2 .
4. Operators: a sign or symbol that Excel assigns to a type of calculation. There are mathematical, comparison, logical, and reference operators. The section entitled “Using Calculation Operators” below contains a list of Operators.	^ (caret) raises to a power * (asterisk) multiplies

Using Constants vs Cell References

Enter constants in formula for unique data only, rather than typing a constant for data already in a cell.

<p>Scenario: Cell A2 contains the constant “50” and cell B2 contains the constant “37.”</p> <p>The formula “=50+37” includes the operator “+” adding constants “50” and “37” with the result of “87.”</p>	
<p>Problem: B2 is changed to the constant “45” but the original formula does not automatically adjust the result. It is necessary to manually change the formula to contain the new constant (=50+45) thereby returning the correct value.</p>	
<p>Solution: The formula “=A2+B2” will always return an accurate value as the formula is adding the values in the referenced cells, rather than adding constant data typed in the cells.</p>	

¹ **Formulas:** A sequence of values, cell references, names, functions, or operators in a cell that together produce a new value. A formula always begins with an equal sign (=), or table (table: A collection of data about a particular subject that is stored in records (rows) and fields (columns)).



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Using Calculation Operators

Operators specify the type of calculation for Excel to perform. There are four types of calculation operators: arithmetic, comparison, text concatenation, and reference. See the tables below for detailed information on each.

Arithmetic			Comparison		
Operator	Meaning	Example	Operator	Meaning	Example
+ (plus sign)	Addition	3+3	= (equal sign)	Equal to	A1=B1
- (minus sign)	Subtraction	3-1	>= (greater than or equal to sign)	Greater than or equal to	A1>=B1
	Negation	-1			
* (asterisk)	Multiplication	3*3	> (greater than sign)	Greater than	A1>B1
/ (forward slash)	Division	3/3	< (less than sign)	Less than	A1<B1
% (percent sign)	Percent	20%	<= (less than or equal to sign)	Less than or equal to	A1<=B1
^ (caret)	Exponentiation	3^2	<> (not equal to sign)	Not equal to	A1<>B1
Text Concatenation					
Operator	Meaning				Example
& (ampersand)	Connects, or concatenates, two values to produce one continuous text value				"North"&"wind"
Reference					
Operator	Meaning				Example
: (colon)	Range operator - produces one reference to all the cells between two references, including the two references				B5:B15
, (comma)	Union operator - combines multiple references into one reference				SUM(B5:B15,D5:D15)
(space)	Intersection operator - produces one reference to cells common to the two references				B7:D7 C6:C8

Order of Operations in Formulas

It is important to understand how formulas are calculated and how changing the order obtains different results. When combining several operators in a single formula, Excel performs multiplication or division before addition or subtraction. If a formula contains operators with the same precedence, for example, where a formula contains both an addition and a subtraction operator, Excel evaluates the operators from left to right.

Formula	Result	Explanation
=4+5*6	34	Excel multiplies 5 by 6 and then adds 4.
=(4+5)*6	54	The calculation above does not return a result of 54 (which would be adding 4 and 5 = 9, then 9 multiplied by 6 = 54).

Use of Parentheses

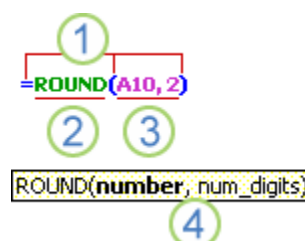
- Enclose in parentheses the part of the formula to be calculated first. For example, the following formula produces 11 because Excel calculates multiplication before addition. The formula multiplies 2 by 3 and then adds 5 to the result.
=5+2*3
- In contrast, if you use parentheses to change the syntax, Excel adds 5 and 2 together and then multiplies the result by 3 to return 21.
=(5+2)*3
- In the example below, the parentheses directs Excel to calculate B4+25 first and then divide the result by the sum of the values in cells D5, E5, and F5.
=(B4+25)/SUM(D5:F5)

Using Functions and Nested Functions in Formulas


Functions are predefined formulas that perform calculations by using specific values and arguments in a particular order or structure. Functions can be used to perform simple or complex calculations.

The Syntax of Functions

The example shown right of the **ROUND** function, rounding off a number in cell **A10** to **2 decimals**, illustrates the syntax of a function. See below for definitions of each element of the function displayed to the right.



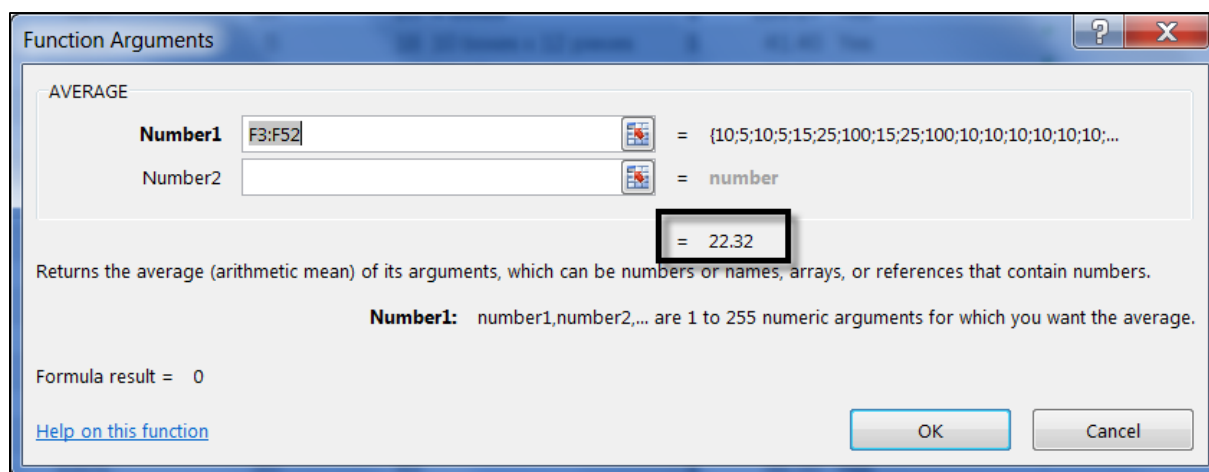
Structure of a Function

1. Structure	The structure of a function begins with an equal sign (=), followed by the function name, an opening parenthesis, the arguments for the function separated by commas, and a closing parenthesis.
2. Function name	For a list of available functions, click a cell and click  the Function button on the <i>Formula bar</i> or press SHIFT+F3. The <i>Insert Function</i> dialog box displays with the list. See the screenshot below in the <i>Entering Functions</i> section.
3. Arguments	Arguments can be numbers, text, logical values such as TRUE or FALSE, arrays, ² error values such as #N/A, or cell references. ³ The argument you designate must produce a valid value for that argument. Arguments can also be constants ⁴ , formulas or other functions.
4. Argument tooltip	A tooltip with the syntax and arguments appears as you type the function. For example, type =ROUND(and the tooltip appears. Tooltips only appear for built-in functions. See second screenshot below in the <i>Entering Functions</i> section.

Entering Functions

1. Insert Function

When creating formulas containing a function, the **Insert Function** dialog box helps you enter worksheet functions. As you enter a function into the formula, the **Function Argument** dialog box displays (shown below) with the name of the function, each of its arguments, a description of the function and each argument, the current result of the function, and the result of the entire formula.



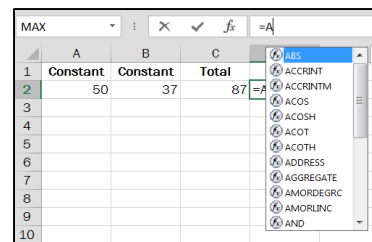
² **An array:** used to build single formulas that produce multiple results or that operate on a group of arguments that are arranged in rows and columns. An array range shares a common formula; an array constant is a group of constants used as an argument.

³ **Cell Reference:** the set of coordinates that a cell occupies on a worksheet. For example, the reference of the cell that appears at the intersection of column B and row 3 is B3.

⁴ **Constant:** a value that is not calculated and, therefore, does not change. For example, the number 210, and the text "Quarterly Earnings" are constants. An expression, or a value resulting from an expression, is not a constant.

2. Auto Complete

To make it easier to create and edit formulas and minimize typing and syntax errors, use formula **Auto Complete** (also referred to as **Argument Tooltip**) (shown right). After you type an = (equal sign) and beginning letters, Excel displays a dynamic drop-down list of valid functions, arguments, and names that match the letters. You can then insert an item in the drop-down list into the formula.



3. Nesting functions

In certain cases, you may need to use a function as one of the arguments of another function. For example, the formula to the right uses a nested **AVERAGE** function and compares the result with the value 50.

- Function interpretation:** If the average of cells F2 through F5 is greater than 50, then add the values in G2 through G5. If not, return the value 0.
- Valid returns:** When a nested function is used as an argument, it must return the same type of value that the argument uses. For example, if the argument returns a TRUE or FALSE value, then the nested function must return a TRUE or FALSE. If it doesn't, Excel displays a #VALUE! error.
- Nesting level limits:** A formula can contain up to seven levels of nested functions. When Function B is used as an argument in Function A, Function B is a second-level function. For instance, in the example above, the **AVERAGE** function and the **SUM** function are both second-level functions because they are arguments of the **IF** function. A function nested within the **AVERAGE** function would be a third-level function, and so on.

1
=IF(AVERAGE(F2:F5)>50,SUM(G2:G5),0)

The **AVERAGE** and **SUM** functions are nested within the **IF** function.

Using References in Formulas

- A reference identifies a cell or a range of cells on a worksheet and tells Excel where to look for the values or data you want to use in a formula.
- With references, you can refer to cells on other sheets in the same workbook and to other workbooks.
- References to cells in other workbooks are called links or external references.⁵

To refer to...	Use...	To refer to...	Use...
The cell in column A and row 10	A10	The range of cells in column A and rows 10 through 20	A10:A20
The range of cells in row 15 and columns B through E	B15:E15	All cells in row 5	5:5
All cells in rows 5 through 10	5:10	All cells in column H	H:H
The range of cells in columns A through E and rows 10 through 20	A10:E20	All cells in columns H through J	H:J

The A1 Reference Style

By default, Excel uses the A1 reference style, which refers to columns with letters A through XFD, for a total of 16,384 columns and refers to rows with numbers 1 through 1,048,576. These letters and numbers are called row and column headings. To refer to a cell, enter the column letter followed by the row number. For example, B2 refers to the cell at the intersection of column **B** and row **2**.

Making a Reference to Another Worksheet

In the example to the right, the **AVERAGE** worksheet function calculates the average value for the range **B1:B10** on the worksheet named **Marketing** in the same workbook.

- Refers to the worksheet named **Marketing**.
- Refers to the range of cells between **B1** and **B10**, inclusively.
- Separates the worksheet reference from the cell range reference.

1 2
=AVERAGE(Marketing!B1:B10)
3

⁵ External reference: A reference to a cell or range on a sheet in another Excel workbook, or a reference to a defined name in another workbook.

Difference Between Relative, Absolute and Mixed References

Relative References

- A relative cell reference in a formula, such as A1, is based on the relative position of the cell that contains the formula and the cell to which the reference refers. If the function is in cell B3, and the first argument is A1, then Excel interprets that as being directed to return the value in the location that is two cells up and one cell to the left of the cell where the cursor is.
- If the position of the cell that contains the formula changes, the reference is changed. If you copy or fill the formula across rows or down columns, the reference automatically adjusts.
- By default, new formulas use relative references. For example, if you copy or fill a relative reference in cell B2 to cell B3, it automatically adjusts from =A1 to =A2.

	A	B
1	50	
2	37	=A1
3		=A2

Absolute References

- An absolute cell reference in a formula, such as **\$A\$1**, always refers to a cell in a specific location. The **\$** is used to indicate a static location to Excel. If the position of the cell that contains the formula changes, the absolute reference remains the same. If you copy or fill the formula across rows or down columns, the absolute reference does not adjust.
- By default, new formulas use relative references, and you may need to switch them to absolute references. For example, as shown in the screenshot to the right, above, if you copy or fill an absolute reference in cell B2 to cell B3, it stays the same in both cells **=A\$1**.

	A	B
1	50	
2		=A\$1
3		=A\$1

Mixed References

- A mixed cell reference is a combination of relative and absolute cell references. As with absolute cell references, the dollar sign (**\$**) is used in mixed cell references to indicate that a column letter or row number is to remain fixed when copied from one cell to another. Use mixed references when you want to copy a formula into both columns and/or rows relative to a fixed row or column. For example, you might have a spreadsheet with a list of equipment and want to calculate the depreciation over a period of time -- where each row contains a piece of equipment and each column a depreciation percentage over a number of years.
- A mixed reference has either an absolute column and relative row, or absolute row and relative column. An absolute column reference takes the form **\$A1**, **\$B1**, and so on. An absolute row reference takes the form **A\$1**, **B\$1**, and so on.
- If the position of the cell that contains the formula changes, the relative reference is changed, and the absolute reference does not change. If you copy or fill the formula across rows or down columns, the relative reference automatically adjusts, and the absolute reference does not adjust.

	A	B	C
1	50	37	
2		=A\$1	
3			=B\$1

The 3-D Reference Style

If you want to analyze data in the same cell or range of cells on multiple worksheets within the workbook, use a 3-D reference. A 3-D reference includes the cell or range reference, preceded by a range of worksheet names. Excel uses any worksheets stored between the starting and ending names of the reference. For example, if you are creating a budget workbook in which you have a separate worksheet (tab) for each month in the Fiscal Year, and you want a summary worksheet that shows the totals for the entire Fiscal Year, your 3-D reference formulas would appear on your summary worksheet similar to the formula below:

=SUM(Sheet2:Sheet13!B5)

This formula adds all the values contained in cell B5 on all the worksheets between and including Sheet 2 and Sheet 13.

- You can use 3-D references to refer to cells on other sheets, to define names, and to create formulas by using the following functions: SUM, AVERAGE, AVERAGEA, COUNT, COUNTA, MAX, MAXA, MIN, MINA, PRODUCT, STDEV, STDEVA, STDEVP, STDEVPA, VAR, VARA, VARP, and VARPA.
- 3-D references cannot be used in array formulas.⁶ 3-D references cannot be used with the intersection operator or in formulas that use implicit intersections.⁷

What happens to 3-D references when you move, copy, insert, or delete worksheets?

The following examples explain what happens when you move, copy, insert, or delete worksheets that are included in a 3-D reference. The examples use the formula =SUM(Sheet2:Sheet6!A2:A5) to add cells A2 through A5 on worksheets 2 through 6.

Action taken...	Result...
Insert or Copy	If you insert or copy sheets between Sheet2 and Sheet6 (the endpoints in this example), Excel includes all values in cells A2 through A5 from the added sheets in the calculations.
Delete	If you delete sheets between Sheet2 and Sheet6, Excel removes their values from the calculation.
Move	If you move sheets from between Sheet2 and Sheet6 to a location outside the referenced sheet range, Excel removes their values from the calculation.
Move an Endpoint	If you move Sheet2 or Sheet6 to another location in the same workbook, Excel adjusts the calculation to accommodate the new range of sheets between them.
Delete an Endpoint	If you delete Sheet2 or Sheet6, Excel adjusts the calculation to accommodate the range of sheets between them.

Using Names in Formulas

You can create defined names⁸ to represent cells, ranges of cells, formulas, constant values, or Excel tables.⁹ A name is a meaningful shorthand that makes it easier to understand the purpose of a cell reference, formula or table. The following information shows common examples of names and how they can improve clarity and understanding.

Example Type	Example with no name	Example with a name
Reference	=SUM(C20:C30)	=SUM(FirstQuarterSales)
Constant	=PRODUCT(A5,8.3)	=PRODUCT(Price,WASalesTax)
Formula	=SUM(VLOOKUP(A1,B1:F20,5,FALSE), -G5)	=SUM(Inventory_Level,-Order_Amt)
Table	C4:G36	=TopSales06

Types of Names

There are several types of names you can create and use.

- Defined Name:** A name that represents a cell, range of cells, formula, or constant value. You can create your own defined name, and Excel sometimes creates a defined name for you, such as when you set a print area.
- Table Name:** A name for an Excel table. Excel creates a default Excel table name of "Table1", "Table2", and so on, each time you insert an Excel table, but you can change the name to make it more meaningful.

By default, names use absolute cell references.¹⁰

⁶ **Array Formula:** A formula that performs multiple calculations on one or more sets of values, and then returns either a single result or multiple results. Array formulas are enclosed between braces { } and are entered by pressing CTRL+SHIFT+ENTER.)

⁷ **Implicit Intersection:** A reference to a range of cells, instead of a single cell, that is calculated like a single cell. If cell C10 contains the formula =B5:B15*5, Excel multiplies the value in cell B10 by 5 because cells B10 and C10 are in the same row.)

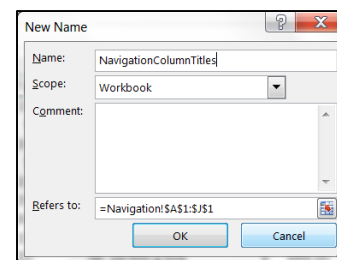
⁸ **Name:** A word or string of characters that represents a cell, range of cells, formula, or constant value. Use easy-to-understand names, such as Products, to refer to hard to understand ranges, such as Sales!C20:C30.)

⁹ **Table:** A collection of data about a particular subject that is stored in records (rows) and fields (columns).

¹⁰ **Absolute cell reference:** In a formula, the exact address of a cell, regardless of the position of the cell that contains the formula. An absolute cell reference takes the form \$A\$1.

Naming a Range of Cells

1. Select the cell range and click **Formulas Tab | Define Name** or right-click on the selection and click **Define Name** from the *Shortcut* menu. The *New Name* dialog box displays (shown right).
2. Click in the **Name** field and type a Name (without spaces). Enter the text of a Comment if desired.
3. Click **OK**.



Entering a Name in a Formula

- **Typing:** Typing the name, for example, as an argument to a formula.
- **Formula AutoComplete:** Use the **Formula AutoComplete** drop-down list. Valid names are automatically listed.
- **Selecting from the Use in Formula command:** Select a defined name from a list available from the **Use in Formula** command in the **Defined Names** group on the **Formula Tab**.

Using Array Formulas and Array Arguments

An array formula can perform multiple calculations and then return either a single result or multiple results. Array formulas act on two or more sets of values known as array arguments.

- Each array argument must have the same number of rows and columns. You create array formulas in the same way that you create other formulas, except you press **CTRL+SHIFT+ENTER** to enter the formula. Some of the built-in functions are array formulas, and must be entered as arrays to get the correct results.
- Array constants can be used in place of references when you don't want to enter each constant value in a separate cell on the worksheet.

Using an Array Formula to Calculate Single and Multiple Results

When entering an array formula, Excel automatically inserts the formula between { } (braces).

Calculating a Single Result

This type of array formula can simplify a worksheet model by replacing several different formulas with a single array formula.

For example, the following calculates the total value of an array of stock prices and shares, without using a row of cells to calculate and display the individual values for each stock.

When you enter the formula `=SUM(B2:C2*B3:D3)` as an array formula, it multiplies the Shares and Price for each stock, and then adds the results of those calculations together.

	Lorem	Ipsium
Shares	500	300
Price	10	15
Total Value	<code>=SUM(B2:C2*B3:C3)</code>	

Calculating Multiple Results

Some worksheet functions return arrays of values, or require an array of values as an argument. To calculate multiple results with an array formula, you must enter the array into a range of cells that has the same number of rows and columns as the array arguments.

For example, given a series of three sales figures (in column B) for a series of three months (in column A), the TREND function determines the straight-line values for the sales figures. To display all of the results of the formula, it is entered into three cells in column C (C1:C3).

When you enter the formula `=TREND(B1:B3,A1:A3)` as an array formula, it produces three separate results (22196, 17079, and 11962), based on the three sales figures and the three months.

1	20234	
2	21003	
3	10000	<code>=TREND(B1:B3,A1:A3)</code>